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MODELING AND SIMULATION OF HYBRID ENERGY SYSTEM USING MPPT FOR IMPROVING POWER QUALITY

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Abstract: This paper describes the combination of wind and solar power by interconnecting it to the Microgrid that stores and transforms DC power. Nowadays, renewable energy is frequently used. Distributed energy sources such as wind power, solar power and so on that can be operated in parallel with a wider utility. Nowadays, most of peoples interested to use renewable energy sources such as tidal energy, solar energy, wind energy, geothermal energy, wave energy, and so on. Generation of DC power is done by a micro grid. This project illustrates the storage and utilization of DC power by using a micro grid. These all renewable energy source generates DC power. By generating these DC power we tend to are utilizing by Microgrid. Operational controls within the micro grids are designed to support the integration of wind and solar power. By these procedure micro grid real time supply and demand are going to be maintain in symmetry. The simulation results are to be developed in MATLAB/SIMULINK process for renewable power generation and fast charging load connected to the dc bus, droop control based responses.
Keywords: Solar Energy System, Wind Turbine System, MPPT Technique, Microgrid system.

I. INTRODUCTION

In the present scenario, renewable energy sources are incorporated along with the battery energy storage systems, which are mostly used for maintain the reliability of power. The number of renewable energy sources is increased as distribution sources; generally, to improve the power supply stability, and hence the power quality new strategies of operations are required. An electrical system that features several loads and distributed energy resources that may be operated in parallel with in the border utility grid is named Microgrid. Micro-grids or hybrid energy systems have been shown to be an effective structure for local interconnection of distributed renewable generation, loads and storage. With the continuing and increasing demand for improved reliability and energy efficiency across all commercial buildings, an amazing chance exists to capitalize on the benefits of DC Microgrid. A Microgrid also consists of distributed energy resources like solar PV systems and wind energy systems that have several electrical loads. The common disadvantage of each wind and solar power plants are as these generate unreliable power1. In order to defeat this problem a latest technique is implemented that is maximum power point tracking algorithm which is applicable to both wind and solar plants. Dynamic performance of a solar and wind system is analyzed. There are some past works on hybrid systems comprising of PV, wind energy and fuel cell have been discussed. All the energy sources are modeled using MATLAB software tool to analyze their behavior. An easy control technique tracks the maximum power from the wind/solar energy source to accomplish much higher generating capacity factors. The simulation results prove the feasibility and reliability of this proposed system.[2, 3]

II. HYBRID ENERGY SYSTEM

2.1 IMPLEMENTATION OF HYBRID ENERGY SYSTEM

Intermittent energy resources and energy resources unbalance are the main reason to install a hybrid solar wind or other energy supply system. The Solar PV wind hybrid system suits to conditions where sunlight and wind has seasonal shifts. As the wind doesn't blow all over the day and the sun doesn't shine for the complete day, using a only one source won't be a suitable choice. A hybrid arrangement of combining the power harnessed from both the wind and the sun and stored in a battery can be a much more reliable and realistic power source. The load is able to still be powered using the stored energy in the batteries even when there's no sun or wind.

Hybrid systems are usually built for design of systems with lowest possible cost and also with maximum reliability. The high cost of solar PV cells makes it less capable for larger capability designs. This is where the wind turbine comes into the picture, the main feature being its cheap cost as compared to the PV cells. Battery system is required to store solar and wind energy produced during the day time. During night time, the presence of wind is an added advantage, which increases the reliability of the system. In the rainy seasons, the effect of sun is less at the site and thus it's suitable to use a hybrid solar wind system.

Figure 1 show the configuration structure for hybrid system based solar and wind energy systems. A rotor in the wind turbine captures the wind's kinetic energy, it consists of two or more blades mechanically coupled to an electrical generator[4]. The mechanical power captured from wind by a wind turbine can be formulated as:

$$P_m = 0.5\rho ACV^3 \quad (1)$$

0.59 is the theoretical maximum value power co-efficient value. It is based on two variables the pitch angle Tip Speed Ratio (TSR). With respect to longitudinal axis turbine blades are aligned at an angle that is the pitch angle. The linear speed of the rotor to the wind speed is TSR.

Wind turbine "C Vs. λ" curve is shown in Figure 2. In practical designs, 0.4 to 0.5 is the maximum achievable range for high speed turbines and for slow speed turbines it is in the range of 0.2 to 0.4.

At λopt its maximum value (C_{pmax}) is shown in Figure 2. Which results in optimum efficiency and maximum power is captured from wind by the turbine.

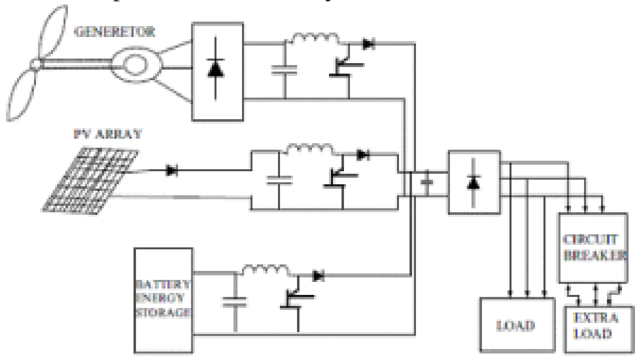

Figure 1.Confguration of Hybrid Energy System

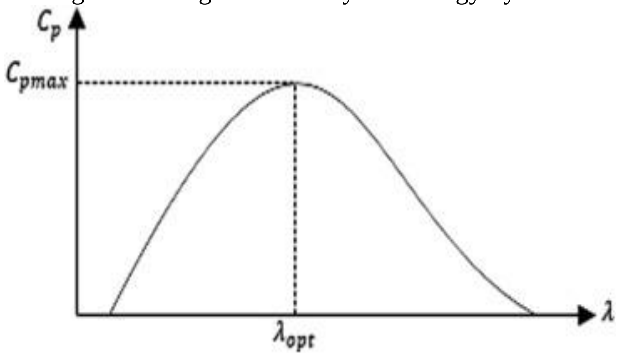

Figure 2.Power Coefficient Vs Tip Speed Ratio

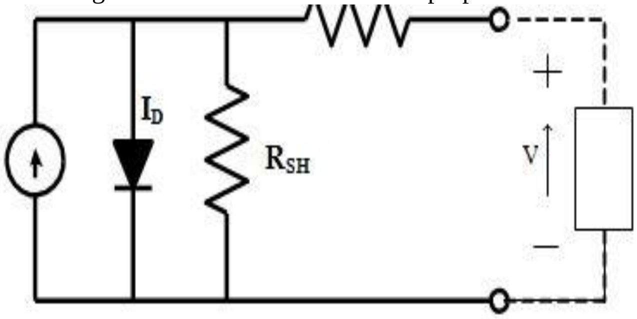

Figure 3.Equivalent circuit of PV Module

In Photovoltaic (PV) system, solar cell is the basic component. PV array is nothing but solar cells are connected in series or parallel for gaining required current, voltage and high power. Each Solar cell is similar to a diode with a p-n junction formed by semiconductor material[5]. It produces the currents when light absorbed at the junction, by the photovoltaic effect. Figure 4 shows an insulation output power characteristic curve for the PV array. It can be seen that a maximum power point exists on each output power characteristic curve.

The Figure 4 shows the (I-V) & (P-V) characteristics of the PV array at different solar intensities. The equivalent circuit of a solar cell is the current source in parallel with a diode of a forward bias. Load is connected at the output terminals. The current equation (2) & (3) of the solar cell is given by[6, 7].

$I = I_{ph} - I_D - I_{sh}$ (2)

$I = I_{ph} - I_o [\exp (q V_D / nKT)] - (V_D / R_S)$ (3)

Power output of solar cell is $P = V * I$

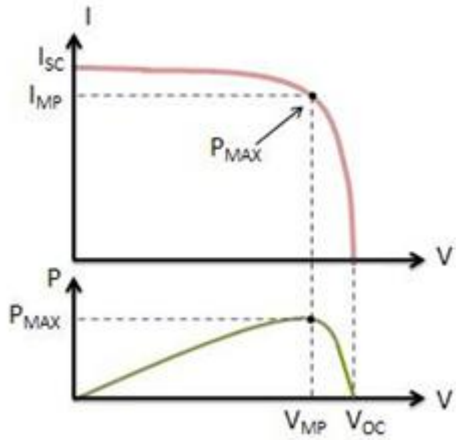

Figure 4.Output Characteristics of PV Array

III. BATTERY ENERGY STORAGE SYSTEM (BESS)

The conversion of Alternating Current (AC) to Direct Current (DC) is made by Battery Energy Storage System (BESS), it has power electronic devices control system and batteries. Here, the working of battery is conversion of electrical energy into chemical energy for storing purpose. By using DC power Batteries are charged and discharged. Bi-directional power electronics devices are regulating power flow between energy systems and batteries8. Based on the type of battery, it has various merits and demerits like cost, weight, size, power and energy capability. Lithium-Ion, Lead-Acid, Nickel Cadmium, Nickel Metal Hydride are important types of energy storage technologies. High discharge rates are achieved by Lead-Acid batteries; these batteries offer a better solution for applications of energy storage. Long cycle life, high energy density, charge or discharge efficiency is high is qualities of sodium sulfur batteries. Nickel Cadmium (NiCd) batteries are better in all qualities and have low maintenance requirements than the Lead-Acid batteries9, 10. However, the costs of these batteries are high when compared to Lead-Acid battery. It is an expensive alternate option. Nickel Metal Hydride (NiMH) batteries are used in hybrid electric vehicles and telecommunication applications because these are compact batteries and light in weight.

The information is processed by the Battery Energy System controller and estimates the State of Charge (SOC) of each battery cell and capacity of each battery cell and protects all the cells operate in the designed SOC range.

On a smaller scale the economic and technical merits of energy storage systems are as follows:

- Electrical supply quality and reliability are improved.
- For critical loads it supplies backup power.

IV. MAXIMUM POWER POINT TRACKING (MPPT)

The efficiency of solar panel and wind turbine are improved by Maximum Power Point Tracking (MPPT) when solar and wind set to operate at point of maximum power. There are different techniques of MPPT. The most popular techniques are: Incremental Conductance method, Perturb and Observe, Fuzzy logic, neural networks. Initial photovoltaic array reference voltage and the initial rotor speed reference for the wind turbine are adjusted if the two systems output power does not match to their maximum powers. We need to adjust the initial reference values in direction of increasing manner of output power and vice-versa. Until the wind turbine and photovoltaic array reach the maximum power points same process repeats. The characteristic power curve for a PV array is shown in Figure 4. If MPPT techniques considered it as a problem, then it finds the voltage V_{MP} or current I and automatically under a given temperature and irradiance the PV array should get the maximum output power P_{MP}[12].

V. SIMULATION AND RESULTS

The complete system design i.e. hybrid energy system is simulated using Simulink. A 10kW wind/solar PV and BESS hybrid system was considered. The simulation study of system parameters are presented below and to predict their actual characteristics three energy sources are modeled accurately in Simulink. Figure 5 shows the simulation diagram for hybrid energy system with solar and wind systems.

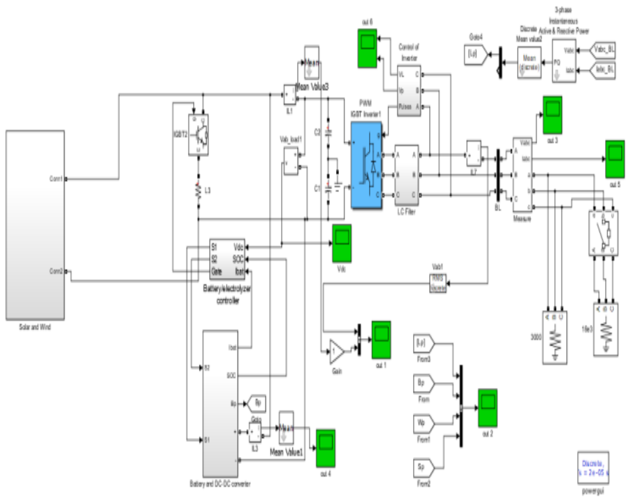

Figure 5.Simulation Diagram for Hybrid PV-Wind and battery System

5.1 SIMULATED GRAPHS

- The load demand to fulfill is 10 KW throughout the time scale except at 4 to 5 sec when it increases to 14 KW.
- Solar energy drops its irradiance to 15 % from 2 sec.
- The Maximum Voltage of PV Array is observed at around 666 V. The curve below explains that the varying irradiance is the deciding factor of the maximum voltage derivations.
- All these conditions are clearly observed in the below graph.

Figure 6 shows the simulation result for output voltage across load terminals. From this result we observed that the voltage changes with respect to change in either the wind or solar plants.

Figure 7 show the simulation result of output current through the load. If the load is changed or suddenly extra load applied to the system then changes occur in the load current. In this paper we suddenly applied the load during the time 1 sec to 2 sec, and then in this period the current rises.

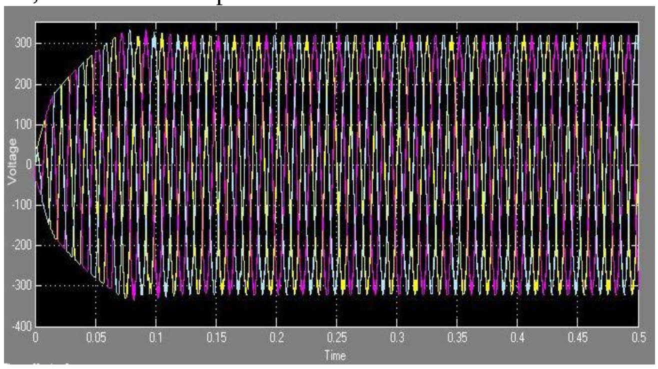

Figure 6.Output Load Voltage

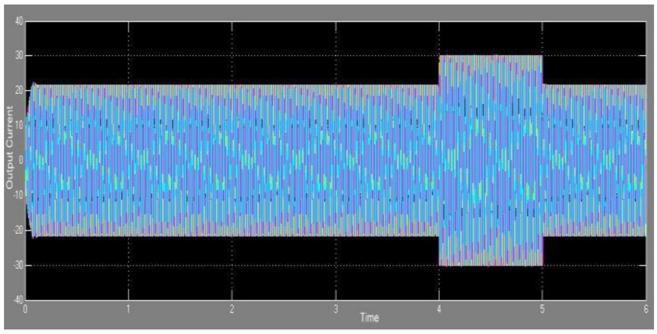

Figure 7.Output Load Current

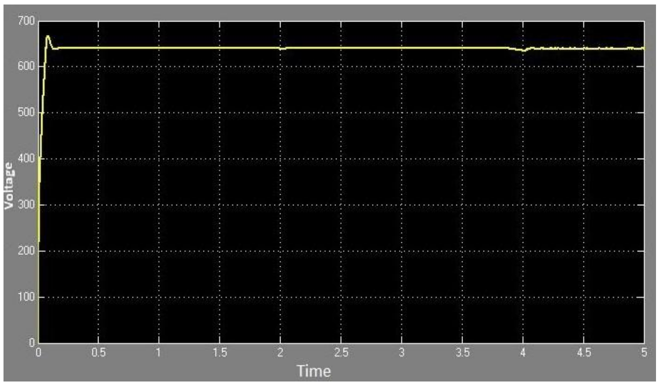

Figure 8. Power Level With Respect to Time

Figure 8 show the power label graph represents of proposed work in which DC voltage is applied and power generated is shown by figure.

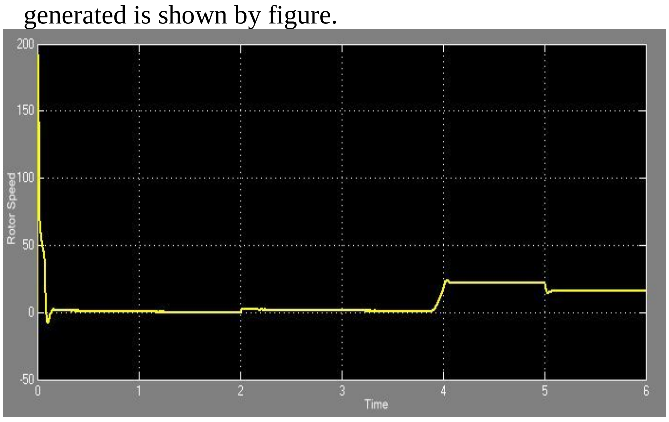

Figure 9.Rotor speed with respect to Time

Figure 9 shows the variation of the speed of rotor. It is seen that according to the wind speed variation, the generator speed varies and that its power to rotating speed of rotor is produced corresponding to the wind speed variation.

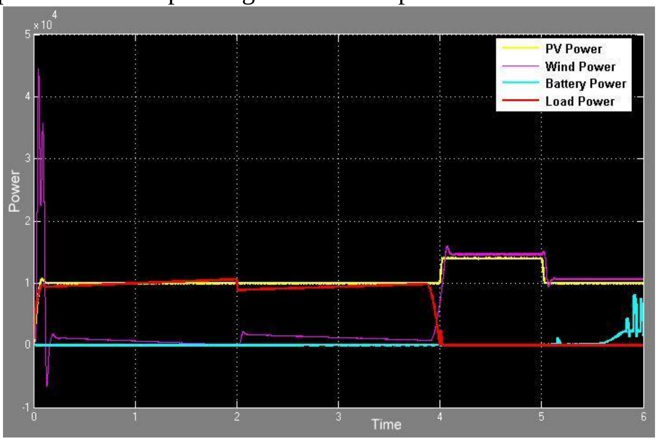

Figure 10.Simulation Result of the Power Management when PV and Wind Supplies Load

Figure 10 shows the power produced by PV and wind is high; the load demand is also high. In this case the PV alone is sufficient to run the load; the excess power from the wind is used to charge the battery through.

VI. CONCLUSION

This proposed work presents the identification and implementation of DC Microgrid with solar and wind as their input source. These renewable sources are integrated into the main DC bus through bi-directional dc-dc converter. Under all operating conditions to meet the load the hybrid system is controlled to give maximum output power. Battery is supporting to wind or solar system to meet the load and Also, simultaneous operation for the same load. The resulting energy system serves local stationary and PV based mobile consumers, and it is a good citizen within the main grid as it reduces emission by local usage of wind and solar energy.

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